Multi Aircraft Control System (MACS)

presented by

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Outline

- What is MACS?
- How does it work?
- What capabilities does it provide?
- How does it interface with other systems?
- What can it be used for and who uses it?
- What are some ongoing enhancements?

- http://human-factors.arc.nasa.gov/ihi/research_groups/air-ground-integration/MacsWeb/HF/MacsWeb.html

What is MACS ?

MACS: Multi Aircraft Control System

- A JAVA program that emulates and simulates current and future air traffic operations in the NAS
- A comprehensive environment for large scale and small scale real-time integrated air/ground simulations
  - Minimum MACS stations for a simulation: 1
  - Maximum MACS stations used in a simulation so far: 38
  - Maximum MACS stations that can be combined: unlimited
- A rapid prototyping environment and test bed for future air traffic concepts
  - Air traffic control and management automation and interfaces
  - Flight deck automation and interfaces
  - Air/ground technologies and procedures
- A system for education and training

What is MACS

- MACS includes:
  - An air traffic simulator
  - A medium fidelity flight deck with full flight management system (FMS) capabilities
  - A high fidelity air traffic controller workstation with advanced automation (Oceanic, Center , and TRACON)
  - An experiment control station
  - A data collection system
  - A scenario generation tool
  - A rapid prototyping environment for new air traffic control and management automation
  - A rapid prototyping environment for flight deck automation
  - An analysis tool
  - A system to run large scale distributed simulations with many operators
  - A standalone application to assess and demonstrate new ATM concepts on any state-of the art computer

MACS in Numbers

- Development
  - 100 % at NASA Ames Research Center
  - Started in 2001 ”from scratch”, because existing tools missed essential capabilities, were too low fidelity, could not easily be modified, or were too expensive

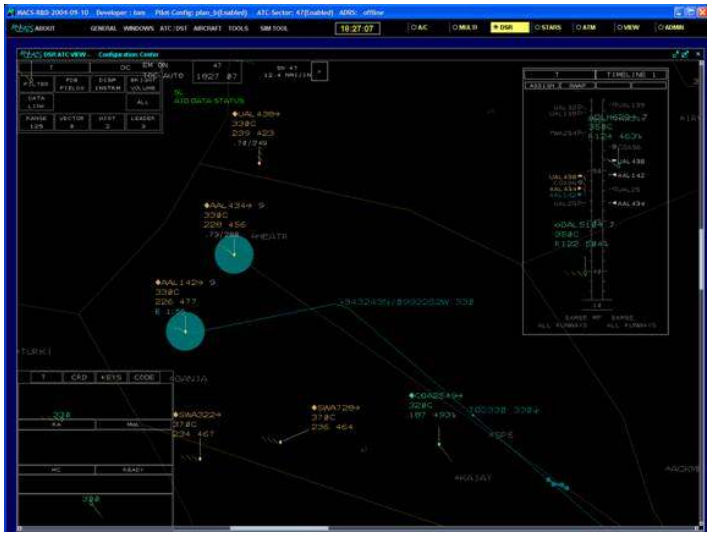
- Size
  - Number of packages (directories): 96 (+ logging and unit tests)
  - Number of source files: 1100
  - Number of classes: 1700
  - Source Lines of Code: ~250,000
  - “Executable” macs.jar: 4.2 MB

- Operating environment
  - Windows XP, ME, NT, 2000, Solaris, Mac OS (X), LINUX, …
  - JAVA 1.5 Recommended min 256 MB main memory, > 1.0 GHZ CPU

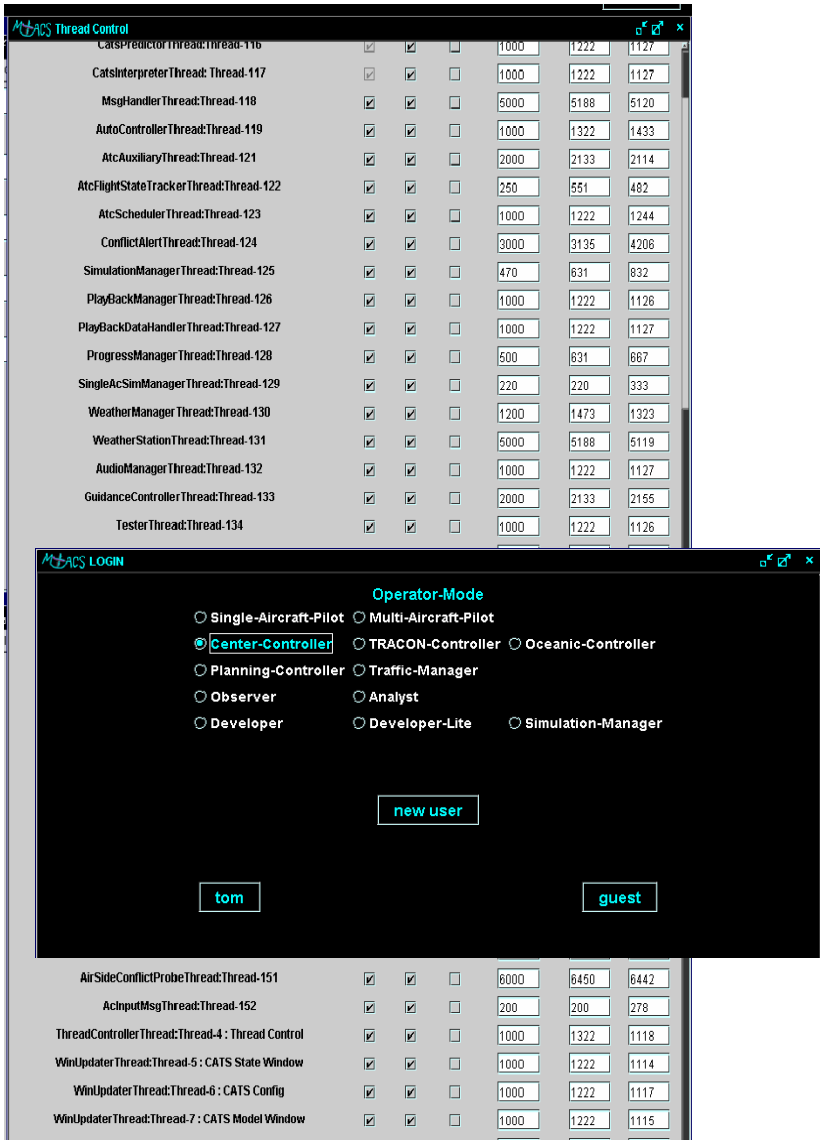
  → Any state of the art computer

What is the Main Idea?

- All operators (human and automation) look at the same situation from different viewpoints
  - MACS maintains a central representation of the air traffic situation and provides access to all the objects stored therein
  - The different viewpoints are realized through a variety of displays and input devices
- All operators (human and automation) need to perform many of the same functions
  - MACS provides a knowledge-base with classes and methods for commonly used functions like route parsers, trajectory generators, performance calculators, etc.
  - Displays and automation access the common knowledge base tailored to each task



How does MACS work?



- Sophisticated Thread Management Process handles over 150 threads
- Each functionality and each window is controlled by its own thread
- 1 of 12 operator modes can be selected
- Only those threads and windows are started that are required for a particular operator mode
  - Low: TRACON-Controller: 52 threads
  - High: Developer: 154 threads

Scenario Generation

MACS internal

Aircraft editor (copy, drag, all values)

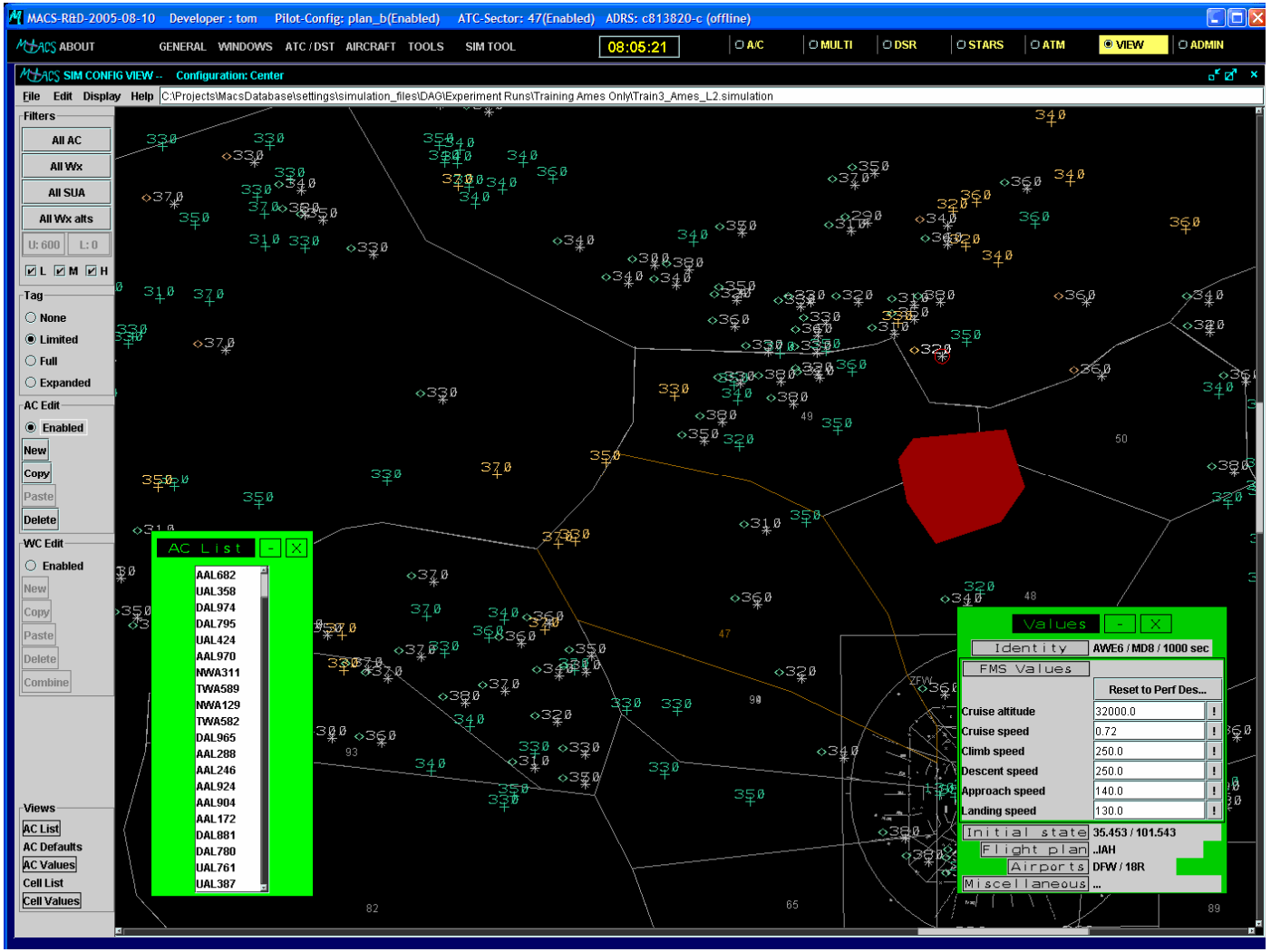
Weather editor (generic, NexRad)

Save as spreadsheet

Can load Dysim files

External:

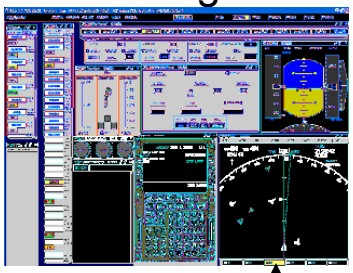
"TCSim" can generate MACS scenarios with desired properties



What can MACS do during a simulation?

Air traffic simulator /target generator

Multi aircraft autonomous agent



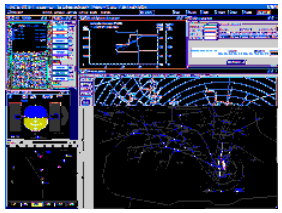
Multi aircraft control flight deck

Single aircraft flight deck (B777 style)

Experiment control

Activity tracking

Aeronautical Datalink and Radar Simulator (ADRS) comm. network

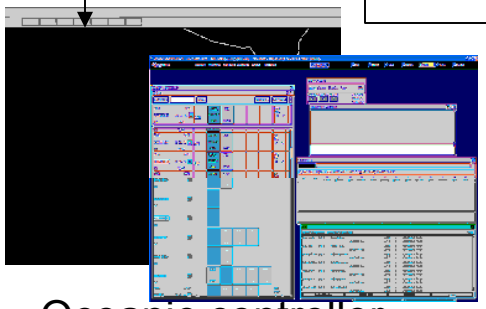


Data collection

Observation

Center controller workstation (DSR)

TRACON controller workstation (STARS)



Oceanic controller workstation (ATOP/Ocean21)

Multi sector controller workstation (DSR based)

ATC emulation

- ATC:
  - High fidelity FAA controller workstation emulations: STARS, DSR, ATOP/Ocean 21
  - Selectable data sources:
    - Perfect, Center radar, TRACON radar, ADS-B
  - Advanced automation:
    - 4D trajectory generation for flight plan routing, scheduling, reported FMS trajectories, ADS-B reported state and flight control system targets
    - Arrival scheduler and timelines
    - Medium-term conflict detection
    - Trial planning and speed advisory functions for metering support
    - Automation for automatic transfer of communication and RTA uplinks

Simulation Pilot Workstations

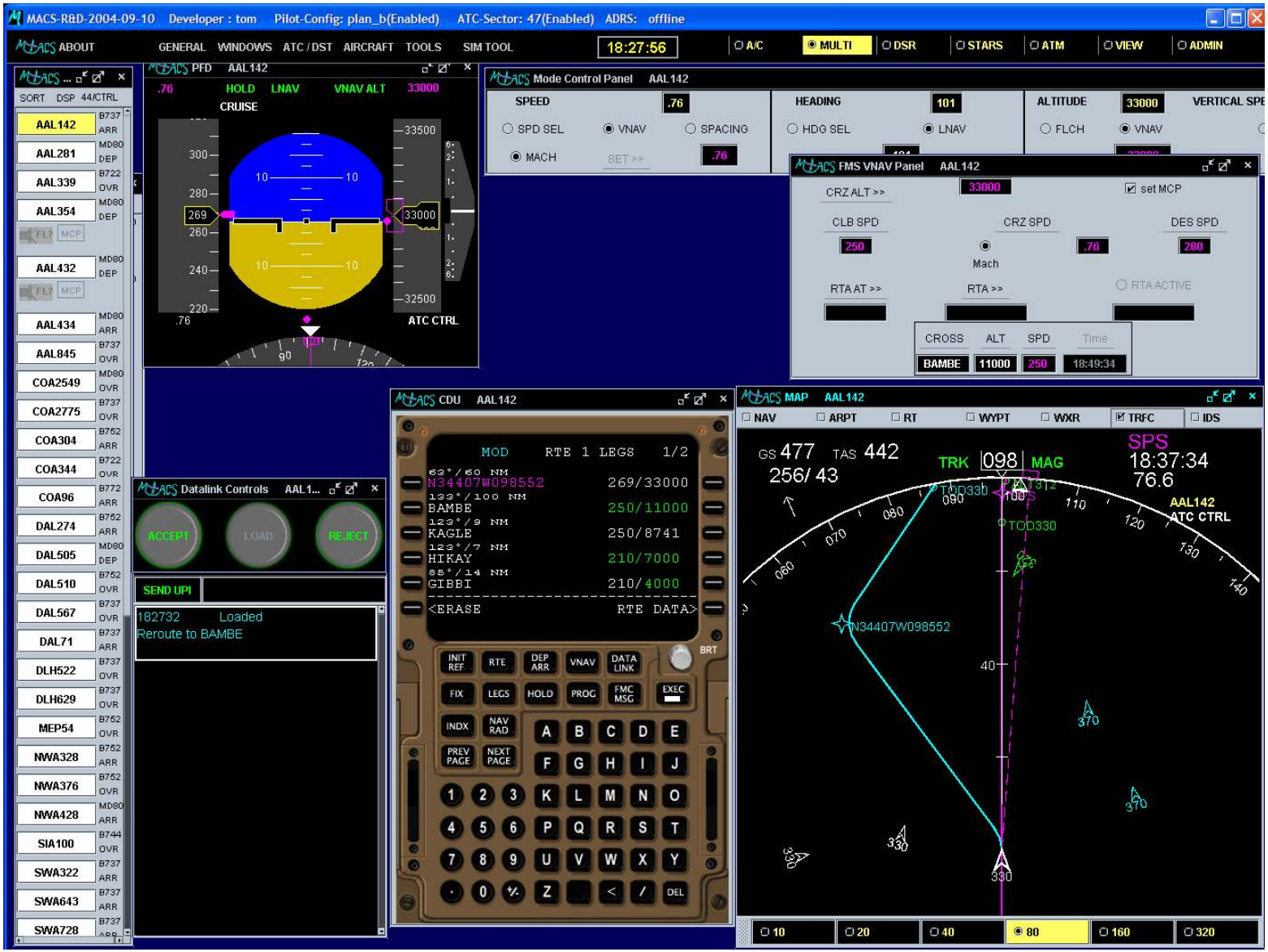
MACS Lab

(D-side positions can be added)

Flight deck

- Flight Deck:
  - Full flight simulator
  - Flight deck for external target generator
  - Performance models for the majority of current aircraft types
  - Selectable equipage
  - Glass cockpit displays
  - Full FMS capabilities with RTA
  - Airborne separation spacing and merging logic
  - Conflict detection logic for (airborne self-spacing)
  - FANS – style CPDLC interface
  - Interface to advanced Cockpit Display of Traffic Information
  - Automatic processing of selected data link messages with predefined delays
  - Agent support for pseudo pilots (reminders or automation)

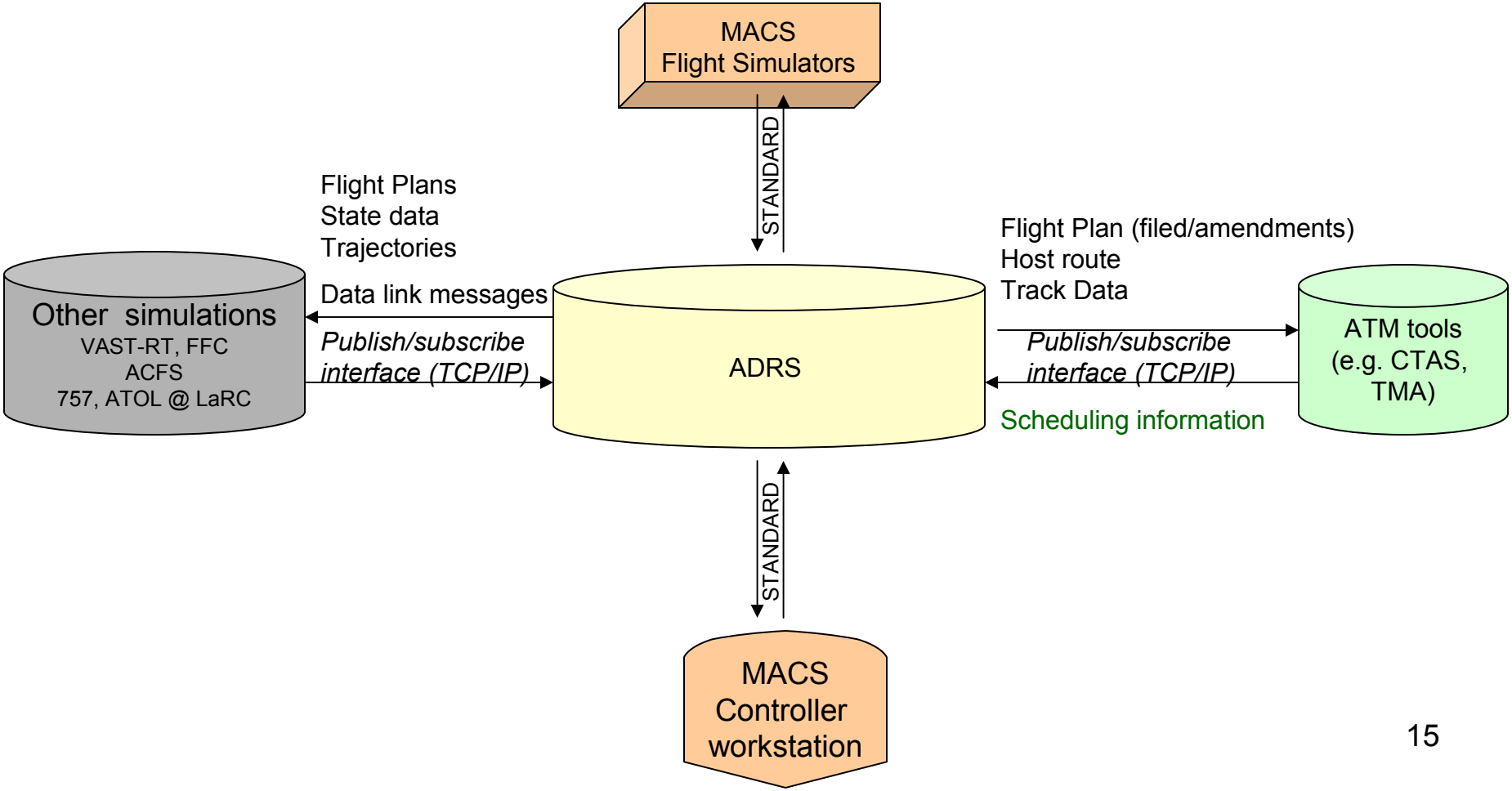
MACS Pilot Workstation



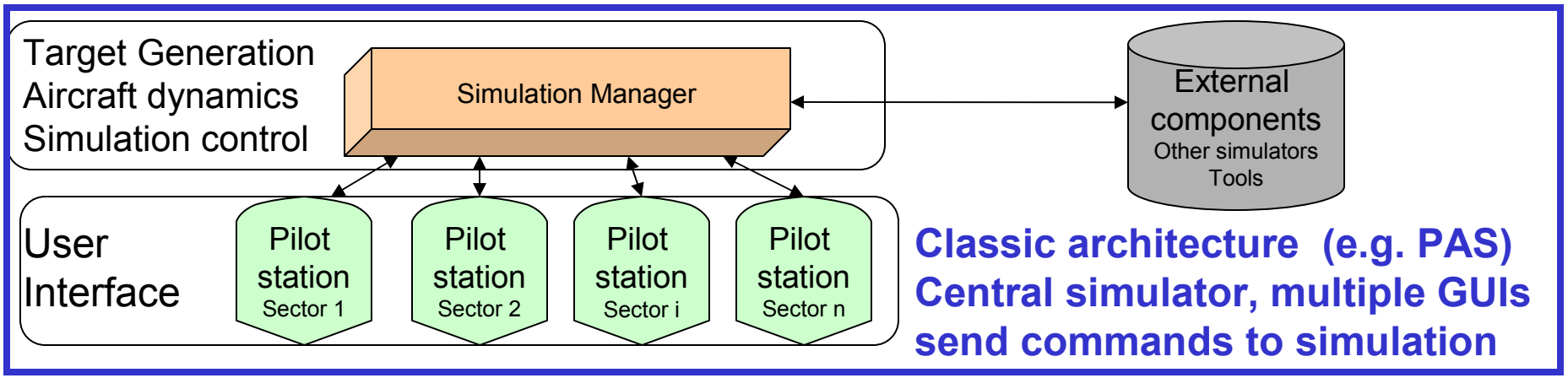
How Does MACS Interface with Other Systems?

All communication is handled by one or more networked Aeronautical Data Link and Radar Simulator (ARDS) processes

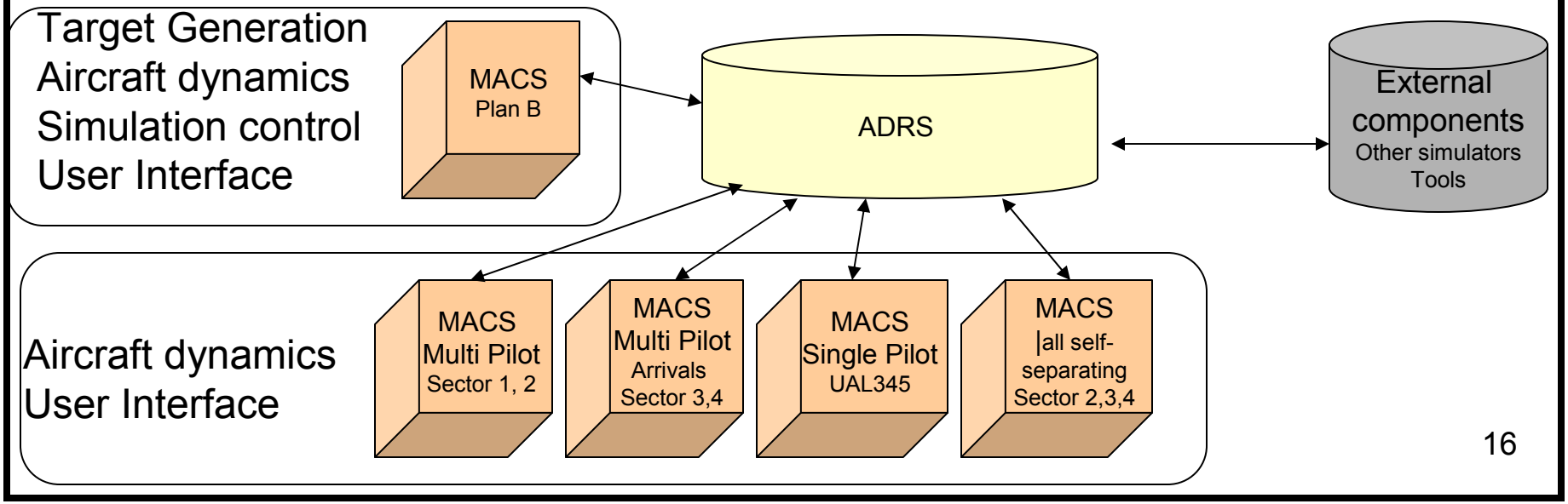
The ADRS provides publish/subscribe interfaces for MACS, other simulators and tools and maintains the entire state of the simulation



Target Generation and Control (MACS)

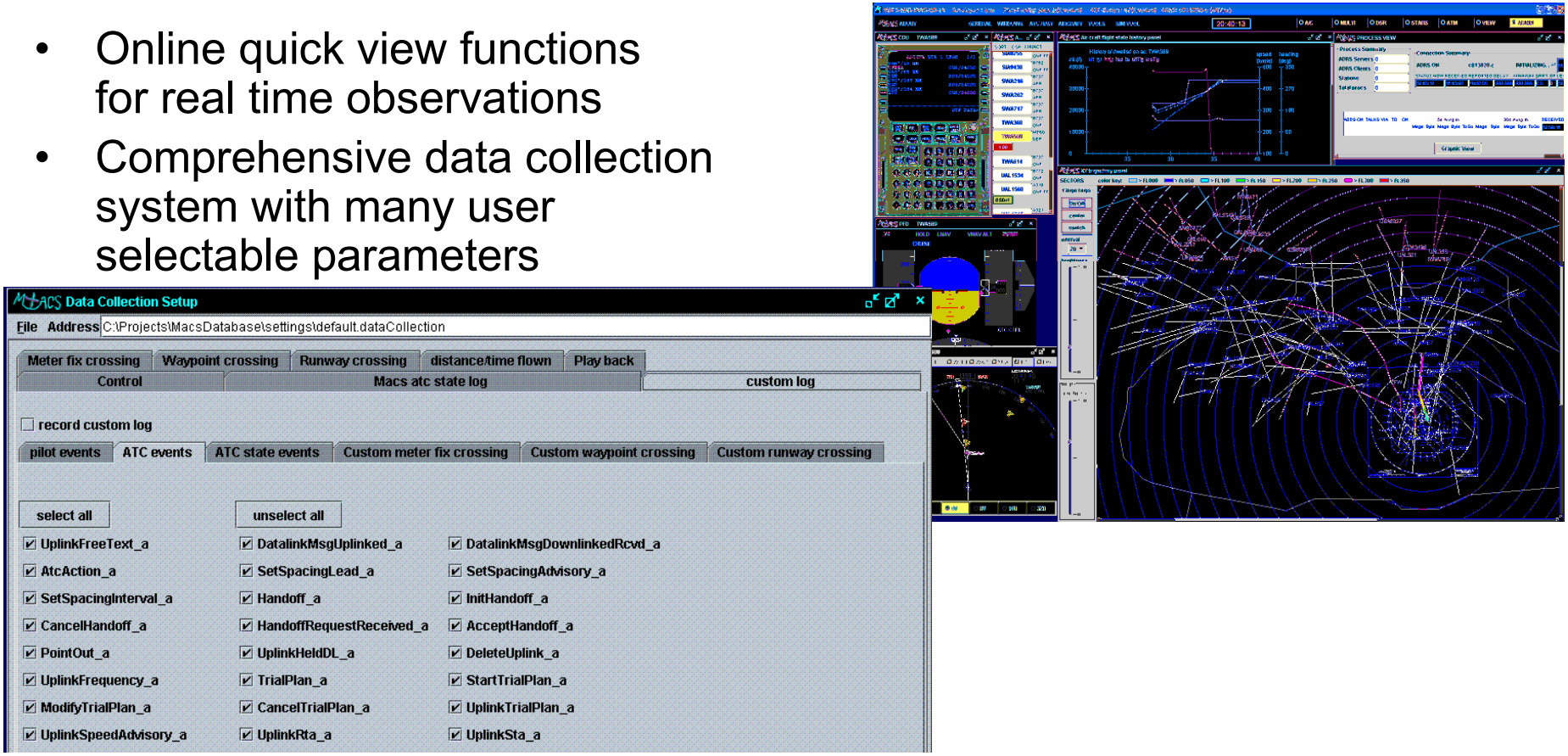


MACS architecture: Each MACS pilot station simulates the aircraft directly. The simulation "moves" with the control from pilot station to pilot station



Data Collection and Analysis

- Online quick view functions for real time observations
- Comprehensive data collection system with many user selectable parameters



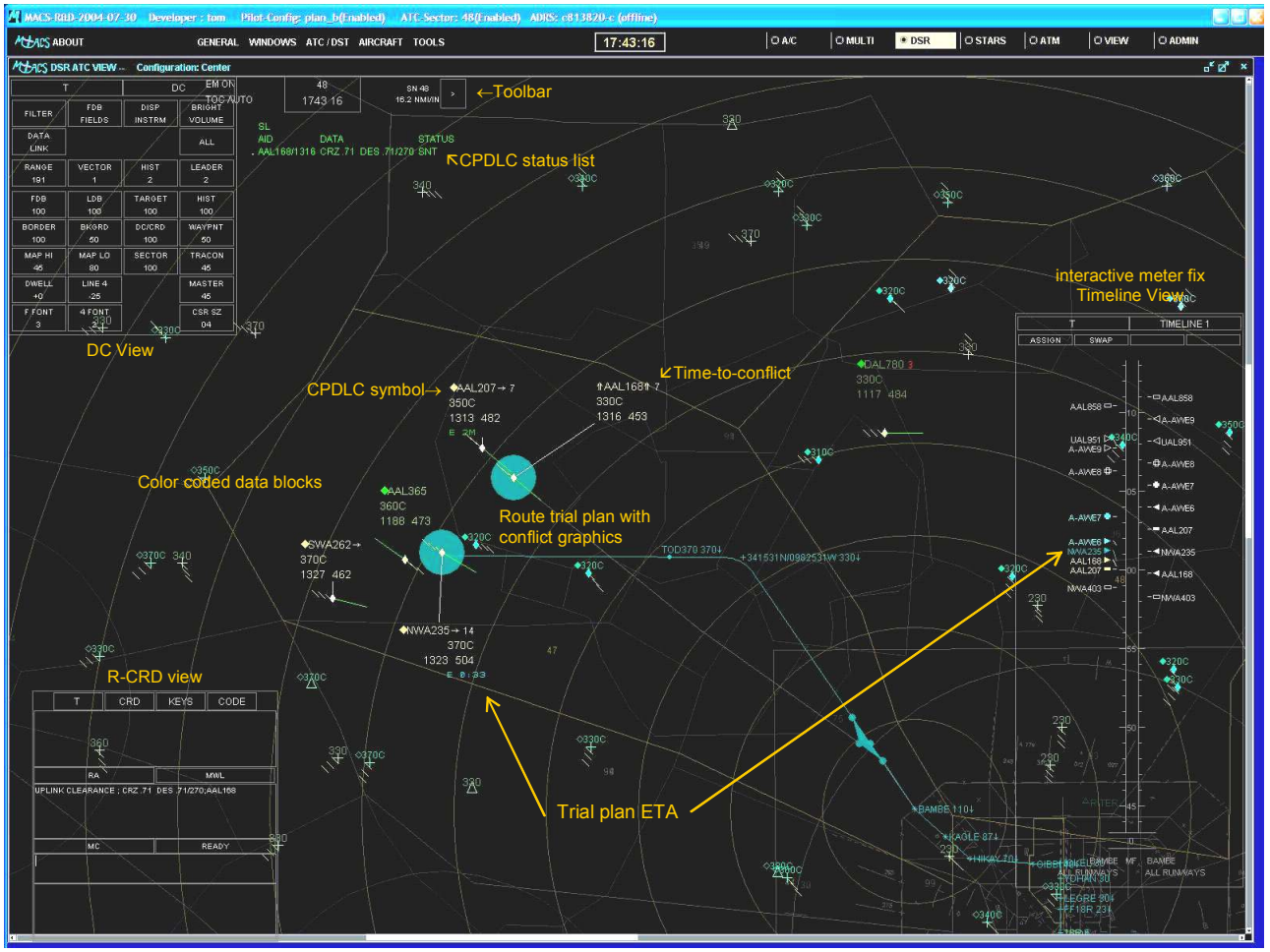
- State and trajectories can be played back through MACS
- Can be processed with “Dproc” program for combined analysis of states, trajectories, and events

Rapid Prototyping with MACS

- "Developer" mode provides all capabilities of the large scale system and can be run standalone
- Easy software development and initial test at the office, at home, or wherever
- Lab test at final development stages required
- Two main development threads:
  - Replication of look and feel, and behavior of existing displays and functions
  - Prototyping of new automation, displays, and display properties of envisioned ATM systems

Rapid Prototyping Example 1

- Integrated Air/Ground System for Distributed Air/Ground Traffic Management



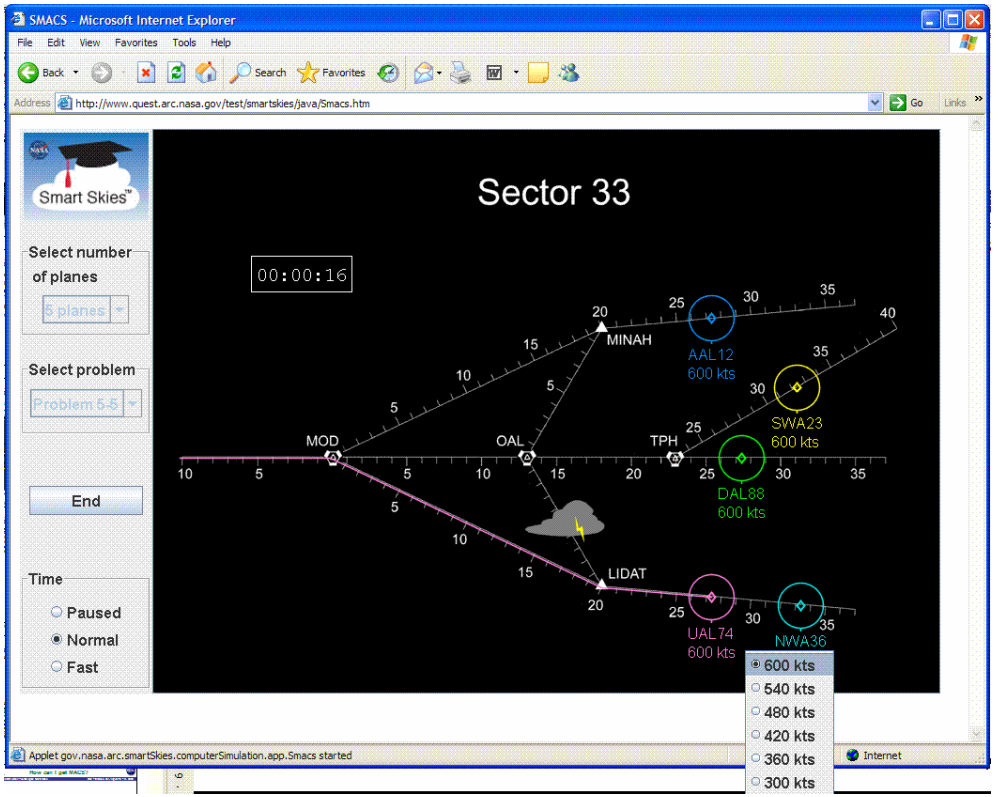
Ground-based and some airborne automation prototyped for mixed operations with airborne self-separation

Tested in joint Ames/Langley simulation with 5 certified professional controllers, 22 airline pilots, and 15 support personal.

Over 30 MACS stations

Rapid Prototyping Example 2

- Smart-Skies Distance-Rate-Time Problems in air traffic control Grades 5 - 9
- MACS-based prototype developed by summer students at Ames
- MACS-version used for initial testing with school kids and shown at NATCA convention
- Design revised
- Web-based application created for education project



Who else uses MACS?

- NASA Ames
  - All ongoing ATM research projects in the Airspace Operations Lab
  - Center-TRACON Automation System project uses MACS as pilot station to add flight management system functionality to target generator
  - Access 5 project uses MACS as controller stations for UAV research
  - MACS was integral part of a demonstration that connected full mission flight simulator, future flight central tower simulator, and airspace operations lab at Ames
- NASA Langley
- Boeing phantom works
- California State University Long Beach
- Northrop Grumman IT
- Seagull, Inc. (now Sensis Corp.)
- Titan, Inc.
- Spectrum Software
- NASA North Texas facility
- ASA Ames University Affiliated Research Center
- California State University, Northridge
- FAA Technical Center
- Dowling College
- Boeing Commercial Airplanes

What are ongoing enhancements?

- Loading of dysim files (90% complete)
- Web version
- Connection to ASDI traffic (5 minutes delayed) with scenario generation from “live” traffic
- Improvements to DSR emulation
- Improved training capabilities
- Integration of new capabilities for NGATS research